**Development of Innovative Techniques for Producing Line-of-sight
Corrected Synoptic Maps with an Application for a UVCS Outflow Velocity Database**

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1. Introduction

The primary goal of this project is to produce a set of outflow velocity maps for the extended corona which cover all phases of Solar Cycle 23. Such maps do not currently exist and the limited regions which have been studied with synoptic data have been used to produce outflow velocities that are averaged over the line-of-sight. For this project, we use a database of more than 10 years of synoptic data obtained with the Ultraviolet Coronagraph Spectrometer (UVCS) on the Solar and Heliospheric Observatory (SOHO). The results of this work can be used to test theoretical models of the solar wind, e.g. Strachan, et al. (2007).

The three major goals for this work are the following: 1) to develop the software tools for computing "localized" coronal plasma parameters (kinetic temperatures and outflow speeds) for hydrogen and oxygen ions in the solar corona, 2) to produce a database of synoptic data for UV line intensities and empirically derived plasma parameters for different coronal structures within the solar wind acceleration region (2-4 R_o) of the extended corona, and 3) to develop a user-friendly interface for data selection and visualization of the coronal UV line intensities and empirical plasma parameters.

In addition to the PI, the project team includes Co-Is Alexander Panasyuk and John Kohl (SAO) and Nick Arge, a collaborator from the Air Force Research Laboratory.

2. Major accomplishments in the last year

During the reporting period, the algorithms for reconstructing the line-of-sight emissivities based on the UVCS Ly-alpha and O VI intensities were completed. This is a major milestone since it is now possible to take a series of daily 2-D intensity maps of the corona and convert these to line-of-sight resolved emissivities through the corona that pass through the UVCS field of view. And example of a reconstruction of the Ly-alpha emissivities near solar minimum is shown in the left panel of Figure 1. The technique can now be applied to data from different phases in the solar activity cycle. We are still investigating the applicability of the technique to periods when the corona is more active (see below).

The image in the right panel of Figure 1 shows the first attempt for reconstructing the variation of the spectral line width along lines of sight through the corona. To our knowledge, this is the first time that line-width reconstructions have been attempted for the solar corona. The method is a natural extension of the tomographic software that was written for the reconstruction of the coronal emissivities (Panasyuk, 1999).
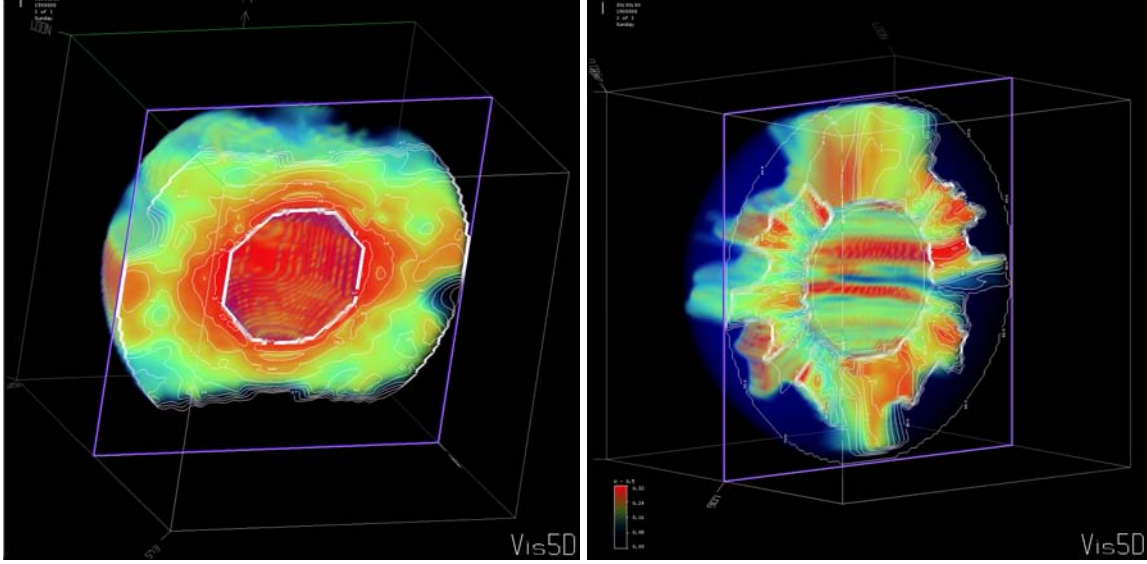
Figure 1. **Left**: Reconstructions of the line of sight emissivity of Ly-alpha in a cut through a 3-D volume of the corona rendered with Vis5d+. The flattening of the emission at the poles indicates the polar coronal holes while the equatorial budge identify the coronal streamer belt. The field of view is approximately 1.5 to 3.5 solar radii. The colors, ranging from dark blue to yellow to red, show increasing Ly-alpha emissivity. **Right**: The first ever 3-D rendition of spectral line widths in the solar corona. The Ly-alpha line widths, when converted to kinetic temperatures will be used to improve 3-D physical models of the solar corona.

3. Summary of activities of the past year.

3.1 Development of the software for the 3-D reconstructions. We have conducted analytical and numerical analyses of the spectral parameters of the solar corona emission, e.g. the local spectral line width and local lines shift. The analytical analysis shows that it is possible to extract line profile shape information from the UVCS data. The purpose of the numerical analysis was for developing a method to optimize the spectral parameters reconstruction algorithm by minimizing the reconstruction uncertainties. Once the analysis showed that the likelihood of success was high, the emissivity reconstruction package was extended to include the reconstruction of the additional spectral parameters. The preliminary results, while encouraging, indicate that the spectral parameters reconstruction is much more sensitive to data uncertainties and coronal dynamics than is the reconstruction for emissivities. Because the spectral line width reconstruction has been smoothed to remove the high frequency dynamics, much of in the information in the original data has not been captured. We are now working on an alternative method for the regularization algorithm.

3.2 Correction for the UVCS instrument effects. Additional numerical procedures were developed to remove instrumental artifacts from the original UVCS Ly-alpha and O VI line profiles. These studies include producing an updated instrument profile function and a precise measure of the dark count rate on the detectors. These procedures were developed to eliminate instrument artifacts in the input data and thereby decrease the level of systematic

uncertainties in the output data. Over the past year, the UVCS calibration was significantly improved which led to much better reconstructions of the emissivities.

3.3 Correction for coronal dynamics. A novel reconstruction algorithm which reduces the influences of short term changes (on the time scale of hours) in the corona was recently developed and is now being implemented. It is based on a combination of multiple "sliding time window" reconstructions. When completed this will allow the reconstructions to be used to make reconstructions for periods where the corona is more active although the reconstructions are still aimed at study state coronal conditions, i.e., coronal mass ejection events are excluded.

3.4 *Development of software for producing outflow velocities from OVI ratios.* We currently use a set of Fortran-based procedures for computing average outflow velocities in the solar corona. These codes require a detailed knowledge of the individual programs in order to obtain the proper outflow velocity results. A new method of computation based on a compact, vector formalism for the redistribution function has simplified the analytical expressions needed to compute the coronal emissivities (Akinari, 2007). The vector formulism is ideal for coding into IDL which handles array manipulation much faster than FORTRAN. We are presently converting the individual software routines into IDL. This will lead to a single, user friendly, routine which can be used to produce outflow velocity data from an input emissivity data set.

4. Remaining tasks.

The remaining tasks for completing the project are identified briefly below: 1) Complete the testing and validation for the line-width reconstructions. 2) Run all of the data through the reconstruction codes to produce a database of emissivities and line widths. 3) Complete the IDL routines for computing the outflow velocities from the LOS-emissivities and compare with the traditional approach that uses standard intensities. 4) Produce the final database of outflow velocity maps for different activity periods of solar cycle 23. 5) Develop and test the data retrieval tools for selecting the data. 6) Document and write a Users Manual to be supplied with the software. 7) Publish the preliminary emissivity, line-width, and outflow velocity maps in an archival journal.

4. References.

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